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# Comparison of bio-efficacy of some plant extracts and new chemistry insecticides against *Bemisia tabaci* (Gennadius) and Water Productivity of Cotton Varieties under High Efficiency Irrigation System

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Cotton is an important cash crop in Pakistan. But insect pests attack and emerging water scarcity glitches are alarming the crop yield on sustainable basis. Hence, the present research trial was executed to probe out the toxic effects of plant extracts and some insecticides against cotton whitefly, *Bemisia tabaci*. Different concentrations of the plant extracts and insecticides were applied. Results showed that highest mean incidence (10.6 adults/plant) of whitefly population was observed in case of BS-15 variety, was under double Lateral+30 cm P×P distance while in case of NIAB-878, the value was 13.1 adults/plant. Results to toxicity bioassays showed that maximum population reduction (79.10%) was recorded in case of pyriproxyfen while comparative less reduction (51.17%) was observed in case of dine to furon after exposure period of 72 (h.). . The values were after 48 and 24 h. In case of plant extracts, highest mortality (51.46%) was noted in case of *A. indica* whereas comparatively low mortality (46.32%) was recorded in case of *M. oleifera* extract at 30% concentration of plant extracts after exposure period of 72 (h.). 20 and 10% concentrations of the tested plant extracts showed relatively lower mortality values. Data of morphological growth showed that plant height got increased by increasing planting distance from 30 to 40 cm in case of the both varieties. Number of leaves and boll size did not increase with increasing planting distance in case of BS-15 variety whileincreased in case of NIAB-878 variety and the values were 105.1 (number of leaves), 44.4 (number of bolls) and 10.2 $cm^2$ (boll size). Crop water productivity of variety BS-15 was higher (0.51 kg $m^{-3}$) as compared to NIAB-878 (0.49 kg $m^{-3}$). It is concluded that the variety BS-15 performed better under single lateral system while variety NIAB-878 performed better under double lateral system. Plant to plant distance of 30 cm was found better than 40 cm distance.
**Keywords:** Cotton varieties, morphogical characteristics, drip irrigation, Planting geometry.

## INTRODUCTION

sThe appropriate supervision of scarcely accessible water, its sensible and effective usage for maintainable irrigated agriculture is the necessity of current era to cope up the food security problem. Agriculture is the assurance for human existence and water is a necessary aspect for crop production. Around 70% of the worldwide water is used for crop production (Yawson *et al*., 2014), 60-80% for irrigation purpose (Ballesteros *et al*., 2016). Nevertheless, the shortage of water capitals is a huge danger to the sustainable agriculture growth (Li *et al*., 2017; Wang *et al*., 2018, Memon *et al*., 2021). Drip irrigation has been known to be a true panacea, which refers to the application of irrigation water in a calculated way according to demand of crop at certain growth stages (Duran-Ros *et al*., 2023). Though it perhaps reduced crop harvests to certain mark but expressively augmented crop water productivity (CWP) (Giuliani *et al*.,

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2016). Moreover, the ever rise in worldwide population not merely upsurges the request for diets but too intensifies the need for fiber products. Cotton is being intensively grown throughout the world owing to its huge socio-economic profits (Hatagale *et al*., 2023) and is the utmost vital crop for fiber (Abdel-Fattah *et al*., 2019). Though cotton is moderately resistant to drought conditions, water is yet a vital aspect for sustaining cotton crop growth and yield of seed cotton can be considerably amplified by appropriate management of irrigation (Zou *et al*., 2023). Hence, to fulfill the necessities of rising population, prudent and supportable irrigation approaches on sustainable basis with minor decrease in crop yields, and upsurge in crop water productivity is the need of the hour. Cotton is the mainstay of the economy of Pakistan. Pakistan produces high-quality fiber to support the textile industry as a leading sector in the country (Sadaf *et al*. 2022). Cotton whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is a worldwide pest of cotton crop, vegetables and ornamental plants (Parola *et al*. 2022; Al-Mallo and Abdul-Rassoul, 2017). It harms the host plant host through sucking cell sap, secreting honeydew that encourages growth of sooty mold on fruits and leaves. It causes a 50% reduction in cotton bolls and is the vector of the famous disease cotton leaf curl virus, with a wide range of host plants (Perier *et al*., 2022). Transmission of viruses is a key problem associated with *B. tabaci* and all mitotypes vary greatly in their ability to transmit viruses. Secondly, the response of mitotypes to diverse insect control tactics too fluctuates (Ali and Ahmed, 2009). *B. tabaci* populations comprises of three mitotypes in Pakistan (Paredes-Montero *et al*. 2020). This insect pest is a main cause of CLCV disease in cotton (Iqbal *et al*., 2018).

Plant protection shares a vital part in the sustainable cotton production and protects it from the insect pest infestation (Bellone *et al*., 2023). In Pakistan, main focus is on spray of insecticides on crops for insect control and is growing each year. Pesticides cost greater than 10 billion rupees described. Pesticides being practiced for insect control in cotton count for 70-80% of total cost (Anonymous, 2008). Moreover, recurrent use of insecticides resulted in resistance development in whitefly worldwide and in Pakistan (Horowitz *et al*., 2020). So, it utmost need of the current era to use the new-chemistry insecticides and botanicals which are target specific, ecofriendly and safe to human health. Use of plant-derived materials to protect agricultural crops against insect pests is not restricted to earliest times. Kumar *et al*. (2019) evaluated some botanicals against cotton whitefly and found neem oil as the highly effect against the insect pest. This tactic is yet practiced by farmers worldwide, typically in areas with inadequate admittance to synthetic pesticides and in organic farming, operating plant extracts and parts like leaves (Mobolade *et al*., 2019). The contemporary research work was planned to check the relative effectiveness of some plant extracts and new chemistry insecticides against whitefly, in the field situations on cotton crop.

## MATERIALS AND METHODS

This research experiment carried out at Water Management Research Farm, Renala Khurd, Okara, with corrodinates; 30.8782° N, 73.5954° E. Impacts of three factors i.e. two varieties; BS-15 and NIAB-878, two planting distance (P-P); 30 cm and 40 cm and two irrigation levels/methods; single lateral per bed and double laterals per bed on water productivity and yield of cotton crop. The research trial about control of whitefly in selected cotton varieties was conducted during 2020 and 2021 at research site of Water Management Research Farm (WMRF), Renala Khurd, Okara. The research trial was laid out as factorial under RCBD design through 3 repetitions. Constant agronomic performs were followed for every treatment. The research work comprised of nominated 6 treatments; three plant extracts (*Azadirachta indica*, *Nicotiana tabacum* and *Moringa oleifera* and insecticides (Dinetofuron, Movento and Pyriproxyfen) laid out in a RCBD by triplicates. Water spray was applied as control. Every of the prepared oil concentrations and synthetic insecticides were sprayed on the cotton crop by means of a knapsack sprayer.


**Figure 1. Field view of cotton experiment at WMRF**

***Plant extracts:*** Plant material extraction, leaves of *M. oleifera*, *A. indica* and *N. tabacum* were collected from premises of WMRF and were shade dried for three weeks. The dried leaves were crushed through an Electrical grinder and extraction was done by Soxhlet apparatus (Guerra *et al*., 2020). After extraction, solvent from the crude extracts was evaporated through Vertical Rotary Evaporator (Model EV311-VAC, LabTech, Italy). The resulting concentrated extract was taken in a small plastic container as a stock solution. The extract of each plant was diluted in solvent to achieve required concentrations (10, 20 and 30%) (V/V) (Fiaz *et al*., 2012). Data regarding *B. tabaci* mortality was recorded afterward 24, 48 and 72 (h.) of the post-treatment.

***New chemistry insecticides*:** Three insecticides; Movento, Diafenthiuron and Pyriproxyfen were tested against whitefly. The description is as under;

**Table 1. Description of New chemistry insecticides .**

| Trade name | Active ingredient | Dose rate |
|---|---|---|
| Movento 240 SC | Spirotetramate | @ 125 1 mL/acre |
| Polo 50%SC | Diafenthiuron | @ 200 mL/acre 4 |
| Progress 10.8% EC | Pyriproxyfen | @ 500 5 mL/acre |

Outcomes were noted down by calculating number of whiteflies adults with the help of a magnifying glass from five arbitrarily chosen cotton plants in an order that single leaf from the upper portion of initial plant, one from the central portion of the next plant and lower leaf of the 3rd plant of alike stage were taken. The recorded values were transformed into means by following formula;

$$\text{Mean} = \sum x/n$$

***Water productivity:*** was calculated by dividing grain yield by total amount of water applied as described by as given below:

$$\text{Water Productivity (Kg/m}^3\text{)} = \frac{\text{Grain Yield (Kg/ha)}}{\text{Amount of water applied (m}^3\text{ /ha)}} \times 100$$

***Statistically analysis*:** The collected data after correction through Abott's formula (1925) =was analyzed through statistically software 8.1 and treatments means were compared by LSD at α=5%.

## RESULTS

Results (Table 1) showed mean incidence of whitefly population in the research trial site. In case of BS-15 variety, maximum population (10.6 adults/plant) was recorded in case of Double Lateral+30 cm followed by Single Lateral+30 cm (8.7 adults/plant), Double Lateral+60 cm (7.2 adults/plant) while lowest population i.e. 7.2 adults/plant was noted in case of Single Lateral+60 cm. In case of NIAB-878, the values were 13.1, 10.4, 9.3 and 6.8 was recorded, respectively. Overall results disclosed that 30 cm planting distance contained relatively more *B. tabaci*.

**Table 2. Mean incidence of *Bemisia tabaci* during the study period**

| Cotton variety | Experimental plot | Mean population /plant |
|---|---|---|
| BS-15 | Single lateral+30 cm | 8.7 |
| | Single lateral+60 cm | 5.7 |
| | Double lateral+30 cm | 10.6 |
| | Double lateral+60 cm | 7.2 |
| NIAB-878 | Single lateral+30 cm | 10.4 |
| | Single lateral+60 cm | 6.8 |
| | Double lateral+30 cm | 13.1 |
| | Double lateral+60 cm | 9.3 |

*Values are means of three replications

Results (Fig.1) revealed that highest population reduction (79.10%) was recorded in case of Dinetofuron afterward 72 h. of treatment application followed by Movento (75.69%) while comparative low reduction (51.17%) was observed in case of Pyriproxyfen afterward 72 h. After 48 h., the values were 65.23, 59.78 and 44.82 %, respectively. Comparative lowest population (31.70%) was recorded afterward 24 h. of Pyriproxyfen spray.

*HAT=Hours after treatment

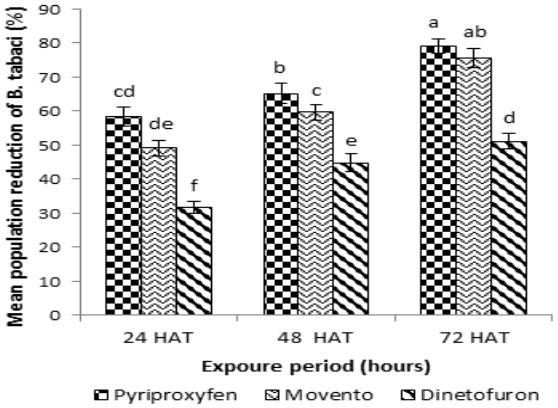


**Figure 1. Mean comparison of data regarding toxic impacts of different insecticides against *Bemisia tabaci* (F=34.56, p<0.05. Vertical bars show error of means. Means sharing different lettering are statistically significant).**

Data (Table 3) showed that treatments impacts were statistically significant (p<0.01). Highest mortality (51.46%) was noted in case of *A. indica* followed by *N. tabacum* (46.32%) whereas comparatively low mortality (46.32%) was recorded in case of *M. oleifera* extract at 30% concentration of plant extracts after exposure period of 72 h. At 20% concentration, the values were 31.45, 29.15 and 24.17%, respectively. Lowest mortality i.e., 19.12% was observed at 10% concentration of *M. oleifera*.

***Results of plant growth parameters*:** Data (Table 1) showed that plant height got increased by increasing planting distance from 30 cm to 40 cm in case of both varieties. Number of leaves and boll size did not increase with increasing planting distance in case of BS-15 variety. However, increased with increased in planting distance in case of NIAB-878 variety and values were 105.1 (number of leaves), 44.4 (number of bolls) and 10.2 (boll size) (Table 3).

**Table 3. Comparative entomocidal impacts of plant extracts against *Bemisia tabaci.***

| Plant extracts | Conc. (%) | 24 HAT | 48 HAT | 72 HAT |
|---|---|---|---|---|
| *A. indica* | 10 | 12.73±1.89 | 22.76±2.43 | 27.13±1.76 |
| | 20 | 13.67±2.78 | 25.52±2.67 | 31.45±1.84 |
| | 30 | 30.42±1.81 | 42.14±2.59 | 50.46±2.71 |
| | Control | 0.00±0.00c | 2.65±1.19 | 2.65±1.19 |
| | F value | 19.82 | 16.78 | 30.12 |
| | P value | 0.001 | 0.000 | 0.002 |
| *N. tabacum* | 10 | 10.21±1.89 | 18.46±2.43 | 23.19±1.76 |
| | 20 | 11.52±2.10 | 20.17±1.65 | 29.15±1.84 |
| | 30 | 22.70±2.41 | 35.89±2.57 | 46.32±2.71 |
| | Control | 0.00±0.00c | 2.65±1.19 | 2.65±1.19 |
| | F value | 16.30 | 12.91 | 24.51 |
| | P value | 0.002 | 0.01 | 0.01 |
| *M. oleifera* | 10 | 7.11±2.17 | 15.34±2.71 | 19.12±1.69 |
| | 20 | 9.76±1.90 | 16.86±3.10 | 24.17±2.54 |
| | 30 | 14.51±1.81 | 26.10±2.78 | 39.46±2.61 |
| | Control | 0.01±0.00c | 1.42±0.11 | 2.13±0.15 |
| | F value | 12.43 | 14.56 | 23.10 |
| | P value | 0.001 | 0.002 | 0.03 |

**Table 4. Growth parameters of cotton cultivars grown under different irrigation regimes.**

| Varieties | PxP distance (cm) | No. of Laterals | Plant Height (cm) | No. of Leaves | No. of Bolls | Boll Size ($cm^2$) |
|---|---|---|---|---|---|---|
| BS-15 | 30 | Single Laterals | 93.9 | 85.5 | 34.9 | 10.1 |
| | | Double Laterals | 92.9 | 80.7 | 30.5 | 10.9 |
| | 40 | Single Laterals | 99.3 | 70.1 | 34.7 | 10.3 |
| | | Double Laterals | 96.3 | 68.3 | 27.5 | 10.1 |
| NIAB-878 | 30 | Single Laterals | 125.5 | 101.5 | 40.6 | 9.9 |
| | | Double Laterals | 118.9 | 88.6 | 35.4 | 10.0 |
| | 40 | Single Laterals | 117.7 | 93.1 | 38.7 | 9.9 |
| | | Double Laterals | 130.1 | 105.1 | 44.4 | 10.2 |

Results of yield/acre showed that highest cotton yield (27.5 maunds $acre^{-1}$) was obtained from NIAB-878 when grown at 30 cm distance under double lateral system/method followed by BS-15 (26.1 maunds $acre^{-1}$) at 30 cm distance plant to plant distance under single lateral system (Figure 1). Low yield (23.3 maunds $acre^{-1}$) was recorded in case of NIAB-878 when grown at 40 cm distance under single lateral system but was superior over control (Figure 2).

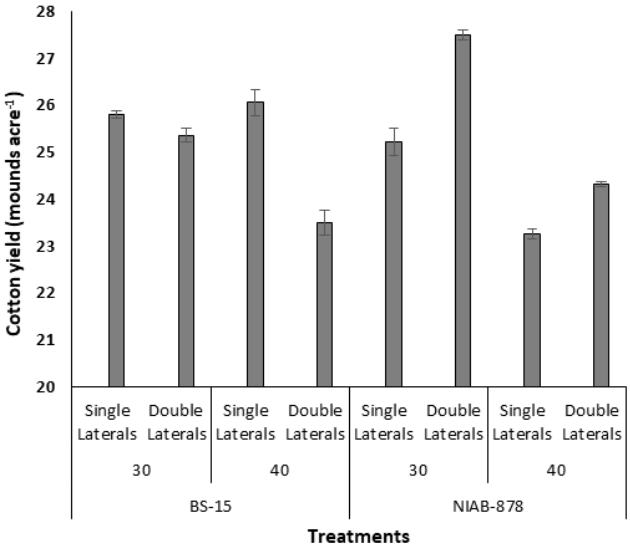


**Figure 2. Yield of Cotton Cultivars Grown with Different Geometry under Various Water regimes**

***Water use efficiency (WUE)*:** The WUE of variety BS-15 was higher (0.51 kg $m^{-3}$) as compared to NIAB-878 (0.49 kg $m^{-3}$). It is concluded that the variety BS-15 performed better under single lateral system while variety NIAB-878 performed better under double lateral system. Plant to plant distance of 30 cm was found better than 40 cm distance. Crop water productivity was comparatively higher than control plot.

## DISCUSSION

Sucking pests result in austere harm to cotton crop every year. In ever-changing ecological conditions, whitefly has become an important insect pest, typically owing to transgenic cotton (Gogi *et al.* 2021). An integrated pest management (IPM) comprising of varied methods is generally suggested for justifiable management (Sain *et al.* 2022). In current research trial, pyriproxifen and spirotetramate were comparatively more operative for whitefly control. The results were corroborated by Kumar *et al.* (2009) who assessed the relative efficacy of acetamiprid, imidacloprid and spirotetramate for the control of whitefly resulting in highest mortality compared with control. The findings the present research work were different to Amjad *et al.* (2009) and Afzal *et al.* (2014) whom found Acetamiprid and imidacloprid as the most effective among the tested insecticides caused noteworthy mortality of whitefly afterward exposure period of seven days. The current results are in line with findings of Mohan and Katiyar (2000) who described that constant application of Imidacloprid caused augmented whitefly

population owing to resistance development in the insect against imidacloprid. Aslam *et al*. (2004) found siprotetramat and pyriproxifen were relatively more effective than the diafenthiuron, acetamiprid and imidacloprid which confirms our results.

There are many non-chemical strategies, comprising of plant-derived chemicals, bacteria, viruses, fungi and nematodes (Gogi *et al*. 2021; Khalifah and Matny, 2013) which can be applied for the control of insect pests. Plants-derived materials are noteworthy factor of IPM as generally economical, target-specific and execute the task better in suitable temperature and eco-friendly (Zafar *et al*. 2016). Our results that plant extracts can control the whitefly significantly are in agreement with previous studies (Mochiah *et al*. 2011). In other studies, variety of plant extract was also found effective against whitefly (Ahmad *et al*. 2009). Results of our research work whitefly mortality (50.46%) about the effectiveness of *A. indica* leaf were close to Kaleri *et al*. (2011) who evaluated the effectiveness of neem extract against whitefly and noted 54.48 % population reduction. Sain *et al*. (2019) reported that suggested dose rate of biopesticides can be made operative under field situations for the control of insect pests. Results of whitefly mortality were low as compared to Sharma *et al*. (2015) who reported 91.90% mortality of whitefly under laboratory condition. The difference may be due to experimental conditions as filed experiments more liable to variations as compared to controlled laboratory conditions. Our results trend of higher mortality afterward 72 h. were supported by Rehman *et al*. (2020) who recorded maximum mortality of *Lipaphis erysimi*, a sucking pest after 72 h. exposure period. Our results were contrary to Hussain *et al*. (2022) who conducted research work on comparative efficacy of plant-derived substances and some insecticides against whitefly and found garlic as more promising rather neem in suppressing the *B. tabaci* population as was recorded in our study.

***Conclusion:*** Biopesticides play a noteworthy part in insect control programs. In the current research trial, outcomes of the bioassays recommended that plant-derived materials and insecticides new chemical composition possessed insecticidal effects against *B. tabaci*. Among the tested insecticides spirotetramat and pyriprofen were more promising in controlling the whitefly. In case of plant extracts, *A. indica* extract was more operative. The current verdicts have convincingly revealed that new chemistry insecticides especially spirotetramat, pyriprofen and plant extract, *A. indica* possessed the capability to be a well-intentioned alternatives to recurrently used insecticides to control the crop damage instigated by *B. tabaci*. Moreover, biorational approach must also be encompassed into the IPM program to keep the insect population below Economic Threshold Level (ETL) and get attack free, green cotton.

***Conclusion*:** From the results, it can be concluded that neem oil was the highly effective against suppressing the population of cotton whitefly. Among new chemistry insecticides, pyriproxyfen was the most promising causing maximum mortality of the targeted insect pest as compared to other tested insecticides. BS-15 performed better under single lateral system with Plant to plant distance of 30 cm while variety NIAB-878 performed better under double lateral system.

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***Code Availability*:** Not applicable

***Consent to participate*:** All authors are participating in this research study

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